THE INFLUENCE OF CHROMATIC LIGHT STIMULATION ON THE SUBSEQUENT RATE OF PERCEPTION UNDER CONDITIONS OF LOW ILLUMINATION[1]

BY H. H. FERGUSON AND T. P. H. MCKELLAR, *from the Psychological Laboratory, University of Otago, Dunedin, New Zealand*

I. *Introduction* (p. 81). II. *Selection of method* (pp. 81–82). III. *The apparatus and precautions taken* (pp. 82–83). IV. *The subjects* (p. 83). V. *Data obtained* (pp. 83–84). VI. *Discussion* (pp. 84–87). VII. *Summary* (p. 88). *References* (p. 88).

I. INTRODUCTION

How is ability to see in the 'dark' related to the quality of the illumination to which the eyes have been subjected? Would different sets of automobile headlights, differing only in chromatic quality, have equally "blinding" effects?[2] Is it a matter of practical importance from the standpoint of visual perception,[3] what quality of illumination is used, for example, in buildings housing personnel who may be required to operate quickly and accurately under 'blackout' or similar conditions? These are the sort of question which the present inquiry set out to answer. The hope that an answer to these questions might prove of practical importance was raised by, in particular, an article by Semeonoff (4), received early in 1942.

II. SELECTION OF METHOD

1. It was desired to approach the problem from the molar rather than from the molecular point of view. We were interested primarily in what *individuals* could and would perceive under certain conditions, not only in how their *retinae* responded. Hence we decided to make no use of, for example, artificial pupils.

2. Since in most real-life situations both eyes are used, it was decided, at least at first, to use a binocular approach.

3. Since there already existed in the laboratory an apparatus capable of subjecting the eyes to diffused illumination of various qualities and intensities, it was decided to make observations in the first instance on the effect of such illumination. This was done in making all the observations here reported.

4. The question of just for how long and under what conditions the eyes should be subjected to the various light stimuli was then considered. The facts of light and dark adaptation were considered at some length. Finally, the following procedure was decided upon.

[1] Based largely on part of an unpublished thesis(3): "The Influence of Chromatic Light Stimulation on the Subsequent Rate of Dark Adaptation", presented to the University of New Zealand in partial fulfilment of the requirements of the Degree of Master of Arts and Honours in Arts by T. P. H. McKellar. A copy of this thesis has been deposited in the University Library, Dunedin, N.Z. My part has been to suggest the problem, supervise the research in a general sort of way, act as a subject and prepare this article. I enjoyed working with McKellar and I desire to thank him most cordially for allowing me to use his material in this way.—H.H.F.

[2] Part of a research project which I suggested to the N.Z. Government Transport Department, Wellington, N.Z., February 1941.—H.H.F.

[3] It is only for convenience in exposition that the term "perception" is used. We appreciate the importance of the contention of those authors who hold that we should speak about "individuals perceiving".

(*a*) For each wave-length the subject was first given a period of 15 min. adaptation to the lowest intensity of the light.

(*b*) He was then asked to fixate the centre of the test object, a rotatable, broken circle of low light value, and indicate as quickly as possible where he perceived the break to be. This was a trial observation to ensure that the subject knew what was required of him. The time taken to perceive the break was not recorded. This trial was given, for the sake of uniformity in every case, that is, even when the individual had previously been subjected to an illumination of a different wave-length.

(*c*) The subject was then submitted to a further 2 min. adaptation and again asked to observe the test object. The time taken to perceive the test object was recorded.

(*d*) The intensity of the illumination was then increased and the subject again tested after 2 min. adaptation.

(*e*) Similarly observations were taken after 2 min. exposures to the remaining available higher illuminations.

To make the procedure quite clear, the following illustration may be cited:

Subject: Mr R. Filters: Red II. Procedure:

1. All room lights switched off.
2. S. submitted to 15 min. exposure to 0·5 foot-candles red II.
3. Red II switched off and S. submitted to test. Trial. Time not recorded.
4. S. submitted to 2 min. exposure to 0·5 foot-candles red II.
5. Red II switched off and S. submitted to test. Time recorded.
6. S. submitted to 2 min. exposure to 1·0 foot-candles red II.
7. Red II switched off and S. submitted to test. Time recorded. And so on.

Briefly, then, the method selected consisted in determining how long each subject took to perceive an object of low light value after both eyes had been exposed to a diffused illumination of known spectral range and intensity for 2 min.

III. The apparatus and precautions taken

1. Illumination readings, taken from a position approximately half-way between that occupied by the two eyes when these were being 'conditioned', were made with a model 614 Weston foot-candle meter. This instrument was equipped with a compensating (Viscor) filter, designed to make the sensitivity of the photronic cell conform to that of the "average human eye"—the norm established by the United States Bureau of Standards(6). Without the compensating filter, the photo-electric cell responds to wave-lengths in the ultra-violet or infra-red regions. This is an important point. The compensating filter removed the excess response of the photronic cell to blues and reds and the instrument gave direct measurements in foot-candles, regardless of the colour composition of the illumination employed.

2. For exposing the eyes to diffused illumination, a hemispherical visual perimeter,[1] 13·5 in. diameter, was used for adaptation purposes. Using this instrument (the inner surface of which was floodlit by four light bulbs) placed so ⁘, it was possible to obtain a highly uniform and extensive visual field. The instrument, designed for perimetric examination of the retinae out to 90°, supplied a stimulus field for the purpose of the present investigations out to, approximately, 100°.

3. To ensure that voltages did not change, readings were taken with a No. 318 P. Ferranti Voltmeter each time the pointer was moved on the resistance scale, connected with the four light bulbs used to floodlight the inner surface of the perimeter. These readings gave secondary voltage, that is, voltage across the four light bulbs. They were in terms of alternating current root mean square volts.

4. Coloured illumination was obtained by inserting filters of ascertained spectrometric quality, in front of the four light bulbs. Preference was given to those filters which covered relatively limited areas

[1] Designed by H. H. Ferguson, 1935 and constructed 1935–6 by G. S. Marshall, Scientific Instrument Maker Dunedin, N.Z.

of the spectrum. Spectral ranges were obtained by means of a Hilger Constant Deviation Spectrometer. Readings were taken using a 100 W. bulb and reflector.

Colours employed in making the observations here described were:

Red	600–660 $\mu\mu$	Blue	433–525 $\mu\mu$
Amber	520–660 $\mu\mu$	White (approximately) ...	400–750 $\mu\mu$
Green	490–600 $\mu\mu$		

5. The test object consisted of part of Dr W. D. Wright's *Test for Night Vision*(7), viz. card No. 2 illumined by the small disk of radium luminous compound, shaded from the direct vision of the subject, incorporated in that test. The card takes the form of a circular grey band on a black background, one small portion of the band being missing. Evidence that the subject sees the card is judged by his ability to give the position of this break, the position being varied by the experimenter. The reasons for the selection of a test object of this form are derived from the experimental work of Von Kries and others into the matter of regional variations in the sensitivity of the retinae. When the centres of these cards in Wright's test are fixated from a distance of 1 ft., the grey band stimulates the most sensitive portions of the dark-adapted retinae. To make sure that all subjects were fixating card No. 2 from approximately 1 ft. and could do so as quickly as possible, a special forehead rest was constructed.

6. The observations here described were obtained in a light-proof room, the walls of which had been painted a dull black.

IV. THE SUBJECTS

These were a selected group in that their standard of living was reasonably high. This point is important in so far as vitamin factors are an important influence on dark adaptation.

V. DATA OBTAINED

The responses of ten subjects, ranging in age from 18 to 61 years, six men and four women, were obtained using red and white. (For the procedure followed, see § II (4).) Table 1 sets out the data thus obtained. Times taken to respond in this and the subsequent tables are given to the nearest second.

Table 1

Red II: 600–660 millimicrons

Subject	Age	Time of response in seconds to illumination in foot-candles of 0·5	1·0	2·0	3·5	6·5	10·0
Mr R.	35	25	21	22	27	27	29
„ S.	20	20	21	25	22	27	28
„ A.	20	51	51	40	58	48	45
„ H.	19	76	70	70	65	70	70
Miss T.	24	21	25	29	24	25	28
„ O.	19	27	28	29	25	29	32
„ W.	26	34	45	39	36	45	35
Mrs M.	61	13	20	21	28	31	35
„ A.	32	45	48	49	45	49	40
„ K.	61	47	55	53	72	70	72
Mean	—	36	38	38	40	42	41

White Light

Subject	Age	Time of response in seconds to illumination in foot-candles of 0·5	1·5	4·0	6·5	18·5
Mr R.	35	21	26	55	55	80
„ S.	20	30	55	72	87	136
„ A.	20	35	57	65	82	99
„ H.	19	96	117	133	190	279
Miss T.	24	40	60	67	80	96
„ O.	19	39	49	79	85	110
„ W.	26	32	51	60	79	160
Mrs M.	61	25	37	54	74	94
„ A.	32	86	93	81	95	180
„ K.	61	82	91	120	150	209
Mean	—	49	64	79	98	144

The responses of five of the above subjects were then obtained using blue. Table 2 sets out the data thus obtained.

Table 2

Blue: 433–525 millimicrons

Subject	Time of response in seconds to illumination in foot-candles of			
	0·2	0·5	1·1	2·0
Mr R.	55	75	85	90
„ A.	99	115	154	230
Miss T.	54	56	91	91
„ O.	67	100	115	119
„ W.	73	87	119	173
Mean	70	87	113	141

The responses of Mr A., Miss W. and Mr R. were then obtained using amber and green. Table 3 sets out the data thus obtained.

Table 3

Amber: 520–660 millimicrons

Subject	Time of response in seconds to illumination in foot-candles of				
	1·0	1·5	4·0	6·5	8·5
Mr A.	63	—	83	90	92
Miss W.	75	73	61	72	81
Mr R.	36	34	37	57	62
Mean	58	54	60	73	78

Green: 490–600 millimicrons

Subject	Time of response in seconds to illumination in foot-candles of					
	0·5	1·5	2·0	5·5	6·4	8·5
Mr A.	83	—	106	101	—	121
Miss W.	92	102	111	130	—	191
Mr R.	56	64	73	85	80	—
Mean	77	83	97	105	80	156

Fig. 1 presents graphically the means given in Tables 1, 2 and 3.

Other important data were collected regarding fluctuations in perception. After the subject had perceived the test object correctly, it did not follow that he continued to see the test object. It might disappear and reappear on several occasions before being continuously visible. The existence of such disappearances and reappearances is well enough known, but the point of special interest in connexion with this investigation is that these fluctuations tended to continue for a longer time after stimulation with illumination from the blue end of the spectrum. Also the disappearances after blue tended to be longer, on rare occasions, as long as 3 min.

VI. Discussion

One of the questions which this research set out to answer was: "Is it a matter of practical importance from the standpoint of visual perception, what quality of illumination is used, for example, in buildings housing personnel who may be required to operate quickly and accurately under 'blackout' or similar conditions?" The data obtained would indicate that it is a matter of practical importance. It would seem probable, in fact, that there is an interesting relationship between "ability to see in the dark" and the order of the colours in the visible spectrum, viz. that intensity of illumination being the same,

the shorter the wave-lengths to which the eyes have been exposed, the longer it takes for an individual to see in the dark.

There are certain 'irregularities' in the data which call for comment. The general rule is that it takes longer to perceive the test object the more intense the adaptation stimulus. Why, then, should some subjects on one or on several occasions take a shorter time to perceive the test object after having been subjected to a more intense light stimulus? Examples of this kind of irregularity are, as will be observed, especially common where red and amber were the adaptation stimuli. It would appear that an explanation of these

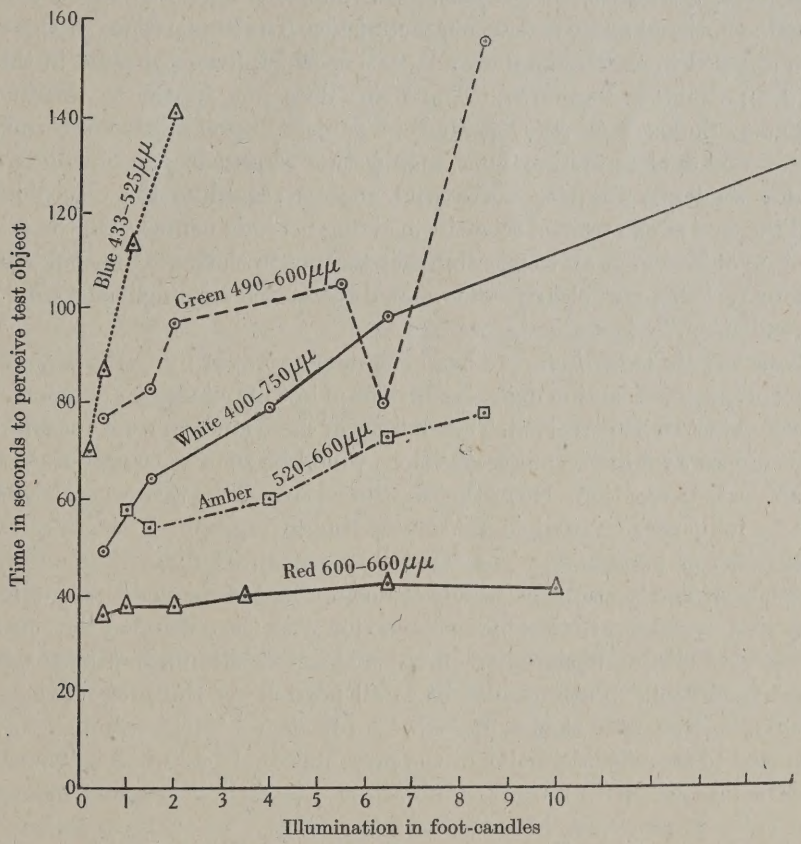

Fig. 1.

irregularities would probably be found under one or more of the following headings: (*a*) the method, (*b*) the mental characteristics of the subjects, (*c*) the nature of the test object, (*d*) fluctuations of perception, (*e*) the limitations of the apparatus employed.

(*a*) *The Method.* It is a reasonable experimental procedure to use the simplest method likely to succeed in doing the task in hand. In so far as the simple method used would appear to have succeeded in determining whether it is a matter of practical importance, from the standpoint of perception under conditions of low illumination, what chromatic quality of light has been stimulating the eyes, the method would appear to have justified itself. Nevertheless, certain inadequacies in the method are most probably responsible to some extent for, at least, some of the irregularities which appear in the data. To have

ensured that each subject made each of his observations with highly similar ocular conditions perhaps the best method, everything considered, would have been, first, to have 'bleached' his eyes by some device such as that employed by Craik & Vernon(1) and then, secondly, to have dark adapted his eyes for a fixed period, immediately prior to adapting his eyes to the special spectral stimuli selected for the purposes of this investigation. It is noteworthy that the majority of these irregularities occur when red and amber were the special stimuli. This was probably because the subjects were still in the process of becoming dark adapted in spite of the increased intensities of the red and amber stimuli.

(*b*) *Mental characteristics of the subjects.* Our subjects were human beings differing in intellectual, emotional and conative characteristics. The implications of this fact have rightly been stressed in articles on dark adaptation which have appeared in this journal (Semeonoff(4, 5); Craik & Vernon(2)). The point does not appear to warrant further elaboration here. Suffice it to say that Mr B., a subject in preliminary experiments, was strikingly slow and deliberate in manner, manifesting persistence, an unwillingness to be hurried and a studied refusal to make wild guesses regarding the test object. "He betrayed all the care of the trained scientist in giving his judgments." On the other hand, Mrs A. "had no objection at all to guessing and was not in the least 'put out' on learning she was wrong". "She was clearly somewhat distractable and inclined to quick movement and vacillation."

(*c*) *The nature of the test object.* As has been demonstrated by Craik & Vernon(2) the speed and accuracy of perception under conditions of low illumination are much influenced by the type of object to be perceived. The findings of these authors would seem to indicate that the test object used in these investigations would be such as to encourage relatively quick and accurate perception. Nevertheless, the nature of the task was such as to leave some scope for influences referred to in the preceding paragraph.

(*d*) *Fluctuations of perception.* These possibly accounted for certain of the irregularities in the data. The 'test object' would 'come up' and 'fade out' alternately. Though such fluctuations were most noticeable in connexion with the colours of the shorter wavelengths, they were also appreciated when red and amber stimuli had been used. In so far as it was impossible to attend closely to all portions of the presentational field at the same time, it is possible that subjects were sometimes 'lucky' enough to be giving special attention to the 'right' portion of the presentational field when it 'came up', thus enabling correct perception of the test object at the earliest possible moment. Conversely, the subjects may have been 'unlucky'.

(*e*) *Limitations of the apparatus.* The only available foot-candle meter, capable of giving readings corresponding to the human eye, was not a finely calibrated instrument. Consequently slight irregularities in the data for the lower illuminations, for example, the intersection of the graphs for amber and white, may be due to incorrect readings of the foot-candle meter. The city electricity supply was used and the voltage of this fluctuated during the day. It was ascertained, however, that only slight irregularities in the data, now presented, and then to be collected, could be expected to arise on this account.

The type of irregularity in the data which has so far been discussed might also be due to the direct and indirect effects of fatigue and also, indirectly, to the somewhat uncomfortable position which it was necessary for the subject's head and shoulders to adopt when he was being adapted to the selected spectral stimuli.

There are a few other points which call for mention in connexion with the above data and their implications.

(i) It will be observed that in the case of blue light the highest illumination to which the eyes were subjected was 2 foot-candles. That was not because higher illuminations were not available, but because some doubt was felt as to the advisability of exposing subjects' eyes to higher illuminations. To be subjected to even 2 foot-candles of this colour was decidedly unpleasant.

(ii) The fluctuations in perception would appear to be worth detailed consideration. Assuming that it is the case that there is a tendency for these fluctuations to be more pronounced and of longer duration after adaptation to short than to long wave-lengths, this would be of some practical importance in connexion, e.g., with night driving and night flying.

(iii) The fact that the extensive field used for adaptation purposes was highly uniform may not altogether have been an advantage. It is possible that it would have been better to have made use of some simpler arrangement, more like the everyday situation.

(iv) The data presented have been obtained under very restricted conditions. Before the full implications, either theoretical or practical, of the present work will become apparent, much more will have to be done. Much more laboratory work is called for to determine the effects of progressively longer and of very long exposures to illuminations differing in wave-length and in intensity. For some purposes it might be considered desirable to use animals as subjects, but that raises many difficulties. The effects of stimulating various areas of the retinae would also have to be considered. It would seem highly desirable, too, to collect data under work-a-day conditions.

(v) While the main original purpose of Semeonoff(4) was to attempt means of facilitating normal powers of dark adaptation, the data now presented would seem to indicate that there is also the possibility of finding means of inhibiting the normal powers of dark adaptation.

(vi) Semeonoff's data(4) showed a "slightly better degree of adaptation with red as compared with blue light", and further that with red, orange and blue illumination, the degree of dark adaptation for all the conditions studied "showed a degree of (dark) adaptation not far short of normal". The conflict between Semeonoff's data and those now presented is probably due to our use of a compensating filter in measuring the intensities of illumination. (See § III (1).)

(vii) Even assuming that the data presented indicate true relationships (which on the whole they probably do) between ability to see under conditions of low illumination and the quality of the illumination to which the eyes have been subjected, the practical applications of these findings would not necessarily be a simple matter. Among other things, one would then have to consider the wastage in electrical power necessarily involved in producing coloured illumination, the differential absorption of different wave-lengths by the atmosphere, the aesthetic effects produced by illuminations of different colours, and the tasks to be performed while under, for example, red illumination. Since all parts of the retinae are not equally sensitive to all wave-lengths, this fact would also have to be considered. Nevertheless it would appear that there are situations in which the present findings, so far as they go, could be used, or at least tried, when provision is being made for interior and exterior illumination.

VII. Summary

1. How does adaptation to illuminations of different wave-lengths influence ability to see in the 'dark'? is the question discussed in this paper.

2. The evidence adduced and considered would appear to support the thesis that, intensity of illumination being constant, the shorter the wave-lengths to which the eyes have been adapted, the longer will be the time taken to see in the 'dark'.

3. It is suggested that there are certain practical applications of this finding, but that in making these, various other factors have to be considered.

Our thanks are due to Dr E. Marsden, Department of Scientific and Industrial Research, Wellington, for help and encouragement; to the University Departments of Physics and Chemistry and to the Dunedin City Electricity Department both for lending apparatus and for helpful advice; to Dr J. N. Findlay for kindly interest and criticism; to the Geology Department for the use of a dark room and to those who were ready to give their time and assistance as subjects.

REFERENCES

(1) Craik, K. J. W. & Vernon, M. D. (1941). *Brit. J. Psychol.* xxxii, 62.
(2) Craik, K. J. W. & Vernon, M. D. (1942). *Brit. J. Psychol.* xxxii, 206.
(3) McKellar, T. P. H. (1942). "The Influence of Chromatic Light Stimulation on the Subsequent Rate of Dark Adaptation." Unpublished thesis. University of New Zealand.
(4) Semeonoff, B. (1941). *Brit. J. Psychol.* xxxii, 136.
(5) Semeonoff, B. (1942). *Brit. J. Psychol.* xxxiii, 1.
(6) Weston Electric Instrument Corporation, Newark. (Circular B 9A, 3–37) (undated.)
(7) Wright, W. D. (1941). *Test for Night Vision.* Pitman.

(*Manuscript received* 7 *June* 1943)

SOME EFFECTS OF COLOURED VEILING GLARE IN BINOCULAR VISION

By R. W. PICKFORD, *from the Psychological Department, Glasgow University*

I. *Aim of the experiments* (p. 89). II. *Apparatus and technique* (pp. 89–94): (*a*) *Apparatus* (pp. 89–90); (*b*) *Technique of the colour brightness experiment* (pp. 90–92); (*c*) *Technique of the veiling glare experiment* (pp. 92–93); (*d*) *Certain constants of the apparatus* (pp. 93–94). III. *The colour brightness experiment* (pp. 94–97): (*a*) *Results of the experiment* (p. 94); (*b*) *Colour vision of the subjects* (pp. 94–96); (*c*) *Discussion* (pp. 96–97). IV. *The veiling glare experiment* (pp. 97–102): (*a*) *Two parallel experiments* (pp. 97–98); (*b*) '*Size*' *and* '*distance*' *methods* (pp. 98–99); (*c*) *Right and left position of the standard* (pp. 99–100); (*d*) *Comparison of colours* (pp. 100–101); (*e*) *Sex differences* (pp. 101–102); (*f*) *Differences of colour vision* (p. 102). V. *Summary and conclusions* (pp. 102–103). *References* (p. 104).

I. Aim of the experiments

In previous articles(1, 2) some of the effects of veiling glare on size and distance perception have been reported. Considerable interest attaches itself to the use of coloured illumination in veiling glare experiments, because of the belief that certain kinds of coloured illumination are better than others for fog vision and that certain kinds of street illumination are particularly disturbing on account of their colour. The experiments had as their aim the attempt to standardize conditions of size and distance perception through veiling glare in which coloured illumination was used, and to determine whether the colours employed had any measurable effects. It will be seen that several subsidiary problems arose, and these will be dealt with at appropriate places. Since the discussions of apparatus and technique are a trifle complex, I shall point out here the essential scheme of the experiments. The subject being tested looked through eyeholes in which colour filters were placed. The filters could be changed as desired. He saw two test objects, one of which was at a standard distance of 3 m. It was viewed through a veiling glare which diminished evenly from it towards the other test object, which was exactly similar in other ways but was used as a variable. The variable was adjusted by the experimenter until it appeared to the subject the same in (*a*) distance or (*b*) size as the standard. Red, yellow, green, blue and white were the colours used, and the effects of these colours on the apparent distance and size of the variable compared with the standard were measured.

II. Apparatus and technique

(*a*) *Apparatus*

The apparatus used was essentially the same as that employed in a previous experiment on the effects of veiling glare in binocular vision(2). Owing to the use of colour filters, which greatly reduce the illumination, certain changes were made. The room illumination was changed to that of a 100 W. daylight lamp, and two similar lamps were used in the lamp compartment of the apparatus. The two lamps in the apparatus were chosen to be as nearly the same as possible. For this purpose a number of lamps were tested, in the apparatus itself, by means of a Holophane-Edgcumbe Auto-photometer kindly lent by the Electrical Engineering Department of Glasgow University. The current from the mains was led through two variable resistances in series and then to the glare lamp in

use at the time (that is to say, either the front or the back lamp in the lamps compartment) and to the room lamp in parallel. The voltage dropped across the two lamps in parallel was measured by an Everett-Edgcumbe sub-standard portable voltmeter, kindly lent by the Electrical Engineering Department. The first resistance was of 1270 ohms (and carried up to 0·6 amp.) and was a coarse adjustment which enabled the experimenter to make large voltage changes easily. The second resistance was much larger in size but of only 260 ohms (also carrying up to 0·6 amp.), and it acted as a fine adjustment, enabling the experimenter to make small voltage changes round about the voltage fixed by the first resistance. A change of 4 V. could thus be made over a large range of voltages and could be read easily on the meter. By this arrangement the room light was dimmed or brightened together with the glare light, an obviously necessary condition, because a proportion of the light entering the eyes through the eyeholes was reflected from the room and from the test objects. Any of the other colours could now be dimmed to the level of brightness of the blue, which was the darkest of them all.

The colours were produced by means of the standard Ilford Monochromatic colour filters, 1·5 in. in diameter, set in 'B' quality glass. The filters used were as follows: 'Spectrum' Red (No. 608), Yellow (No. 606), Green (No. 604) and Blue (No. 602). The transmission bands of these four filters are:

Blue	4400–5000 A.	Yellow	5600–6300 A.
Green	5000–5500 A.	Red	6200 A. to end of spectrum.

These colour filters correspond well with the familiar psychologically primary colours, and do not overlap (except for the red and yellow, the overlap of which is negligible because very little light is transmitted in the overlapping portions). The red is rather more tinged with orange than 'pure' red. Yellow was included as a fourth colour because of its unique appearance. Orange is acceptably described as reddish yellow; yellow-green as yellowish green; peacock as bluish green or greenish blue; violet as purplish or reddish blue; but yellow is not conceivably to be described as reddish green except by certain red-green blind subjects.

The colour filters were used in pairs, two filters of the same colour being placed one before each eyehole of the apparatus, in a special holder made of cardboard which fitted tightly into the head-rest described in the previous paper (2). Thus the subject, on looking at the test objects through the filters, saw the whole field of vision coloured by the filtered light, while the fog effect, also coloured, of course, was graded from right to left or from left to right according to the use of the front or back lamp in the lamps compartment.

(*b*) *Technique of the colour brightness experiment*

Different colours, though possibly transmitting equal amounts of luminous flux, are well known to be of different brightnesses compared with each other or with a standard such as white. The absorption curves of different colour filters vary according to the properties of the individual filters. Full details of the physical properties of the Ilford Colour Filters may be found in the descriptive booklet (3), and a glance at the absorption curves of the standard monochromatic filters shows that the percentage transmission of its own portion of the spectrum by each filter used in this experiment is greatest by the red, less by the blue, less again by the green and least of all four by the yellow. This order of percentage transmission partly compensates for the relative brightnesses of the corresponding colours in normal vision and daylight adaptation, so that the red,

yellow and green filters do not differ greatly in brightness, but it is still true that the blue is much less bright than any of the other three. The white light used in this experiment was produced by the 100 W. daylight lamps, and, not being filtered at all, was much brighter than any of the other four. This white is somewhat more yellow than perfectly white daylight, although so-called daylight lamps look blue in comparison with ordinary half-watt lamps.

It is perhaps less commonly recognized that the relative brightnesses of various colours differ considerably, from one individual observer to another. This matter of individual differences is most familiar in the protanopes, the scoterythrous group of red-green blind subjects, for whom red tends to be greatly darkened and is often confused with dark grey or with black. Less marked variations in colour brightnesses are also found among persons with no defect of colour vision. In order, therefore, that the conditions of the experiment should be standardized it was necessary to allow for the differences in percentage transmission of the colour filters (and the white light) and also for the individual differences in colour brightnesses.

The blue was decidedly the darkest of all the colours used, and it was therefore taken as the standard, with the full voltage of the mains (250 V.). For each of the ten subjects a series of brightness determinations of the four other colours, red, yellow, green and white, was made against this blue standard on his first sitting. For this colour brightness experiment a rearrangement of the wiring of the apparatus was necessary. The back lamp of the lamps compartment was connected directly to the mains, and gave the standard lighting for the blue filter because a wooden partition was fitted so that each eyehole was illuminated by veiling glare coming from a separate lamp. The front lamp of the lamps compartment and the room lamp were connected in parallel together and through the two resistances in series to the mains. The voltage dropped across the terminals of this pair of lamps was then measured by the voltmeter. Now the blue filter, placed in the right eyehole, was illuminated by the standard illumination, and any of the other filters, placed in the left eyehole, was illuminated by the variable light coming from the front lamp and the room lamp together. The subject sat upright on the stool and viewed the eyeholes from a distance of half a metre. The left hole was seen as a patch coloured with the light transmitted by the red, yellow or green filter, as required, or illuminated by the white light, and the right eyehole was seen as a standard blue patch. The subject was instructed that it was necessary to determine the voltages at which each comparison colour would appear the same in brightness as the blue, though different in hue, of course. He was shown that the variable colour could be made much brighter or dimmer than the blue at will by the controlling resistances, and six sets of readings were then taken by the limiting method, using steps of 8 V. The colours were taken in the order green, yellow, red and white, because most subjects found green easily compared with blue, but Subjects 1 and 6 took yellow before green. The separate readings of the three ascents and descents were always very close, and this experiment is a simple and efficient method of comparing the brightnesses of colours. It must be remembered, however, that the colour filters have different percentage transmission bands, and the blue, though dimmest in appearance, transmits much more blue light than the yellow does yellow light, and the other colours vary as described before. Hence comparisons of colour brightness by this method are no more absolute than are those obtained with coloured papers on the Marbe rotator (in spite of the fact that the colour filters are almost mono-

chromatic and the paper disks are not), but they are valid within the conditions of the experiment. In the veiling glare experiment it was now possible to use the colours at the brightness values in terms of voltage which each individual subject had himself equated with the blue. By this means we can be reasonably sure that there are no unwanted brightness differences between the colours for each subject, though such differences would have been marked if this preliminary experiment had not been done.

(*c*) *Technique of the veiling glare experiment*

Except in the details which are given in this article the apparatus and set-up of the experiment were the same as in the previous research already mentioned(2). The subject looked through two eyeholes at two white disks, 11 cm. in diameter and about 60 cm. apart, mounted on black stands which were invisible and resting on a black table. The two disks were seen, one more veiled than the other by the glare, against a black background, and either of them could be moved towards or away from the subject by the experimenter, always being at right angles to the line of vision of the 'cyclopean' eye. Thus either disk could be used as a standard, placed at 300 cm. distance from the eyes, and the other as a variable. The disks were arranged to slide against metre sticks attached to the table, and the distance of either disk could be read by the experimenter. The limiting method was used, because it is the quickest, the most flexible and the most natural of the psycho-physical methods. The experimenter moved the variable step by step, starting at a position at which it appeared definitely nearer than the standard, and making six ascents and descents in most cases. Sometimes the number was only five or even four if the subject seemed very reliable, but these reductions were very seldom made, and only in the early stages of the experiment, because for statistical purposes it is best to have not less than twelve estimates of equality. Even twelve is a small number, but the advantages gained by taking more readings would have to be set off against the disadvantages of making the whole experiment intolerably prolonged. The steps taken were usually of 2 cm., but with some subjects larger steps were necessary, even 5 cm., otherwise vagueness of judgement would have been produced and the experiment would have become extremely tedious. In choosing the size of the steps the criterion was that at least one and not more than two points of equality should be obtained as a general rule for the subject being tested.

It has been seen that results of such an experiment are not appreciably affected by practice(2). Hence the general plan of the experiment was to have several sittings for each subject. In the first sitting the method of the experiments was briefly explained and the brightness estimates were made. In the other sittings the complete series of tests were made. Only a quick subject could get it all done in three sittings, and most of them had four or even five. It is a tedious experiment, and I am grateful to the subjects for working through it patiently.

The gradient of the veiling glare was always arranged so that the standard was under more glare than the variable. At first the subjects were asked to estimate whether the variable was apparently nearer than, as far as, or farther than the standard. The plan of the experiment was as follows: first, glare greater on left, standard on left, variable starting nearer; second, glare greater on right, standard on right, variable starting nearer. This gave 'left' and 'right' readings, which were recorded separately, and the colours were taken in turn in the order Blue, Yellow, Green, Red and White, the brightness of

each being adjusted according to the results of the preliminary experiment for the subject in question. After this the whole series was repeated with the instructions to estimate whether the variable looked larger than, equal to, or smaller than the standard, irrespective of apparent distance.

In order to obtain some idea of the reliability of the experiments, it was decided to repeat the whole series, including the brightness measurements, after an interval of at least 3 weeks. The data obtained throw light on the following questions: (*a*) whether the effect of the differential veiling glare on distance and size perception varies in consequence of the colour used, (*b*) whether the left or right position of the standard has any effect, (*c*) whether the 'size' or 'distance' methods have different effects, (*d*) whether a repetition of the experiment produces the same or different results.

Of the ten subjects used three were men and three were women with normal colour vision; one was a man with a peculiarity of green and yellow vision; one was a woman with a slight weakness in blue vision; the remaining two were both very red-green blind men. Fuller details of their colour vision will be given later. The experiment would therefore be expected to throw light on the differences, if any, between men and women and upon any effects which the abnormalities of colour vision mentioned may have had.

(*d*) *Certain constants of the apparatus*

The following photometric measurements were made with a Holophane-Edgcumbe Auto-photometer kindly lent by the Electrical Engineering Department. They apply

Table 1. *Illumination of test disks*

Distance from eyes	Voltage	Foot-candles
300 cm.	250	4·0
300 cm.	100	0·1

Table 2. *Illumination of milk glass plate*

	Illumination in foot-candles, with position of photometer cell			
	Opposite R. lamp		Opposite L. lamp	
Voltage	R. lamp on	L. lamp on	R. lamp on	L. lamp on
250	65·0	—	30·0	—
	—	30·0	—	65·0
100	1·10	—	0·55	—
	—	0·50	—	1·20

Table 3.

	Illumination in foot-candles		
Voltage	At milk glass plate	At eyeholes	Ratio
100	1·55	0·04	39/1
120	4·40	0·10	44/1
140	9·20	0·24	39/1
160	17·90	0·45	40/1
180	29·50	0·75	39/1
200	51·50	1·19	43/1
220	71·50	1·69	42/1
240	101·50	2·40	42/1
250	117·00	2·71	43/1

only to the exact set-up of apparatus described in this paper. From Table 1 it will be seen that a reduction of the voltage from 250 to 100 reduces the illumination of the test objects from 4 to 0·1 f.-c. From Table 2 it is seen that the gradient of the veiling glare is such that the glare is rather more than twice as great on one side as on the other, whichever way it slopes. From Table 3 it will be seen that the veiling glare at the inside of the box between the eyeholes is consistently about one-fortieth of its intensity at the diffusing screen, between the voltages of 100 and 250, when both lamps in the lamp box are switched on together.

III. The colour brightness experiment

(*a*) *Results of the experiment*

Table 4 shows the brightnesses of the four colours green, yellow, red and white in terms of voltage, compared with the standard blue at 250 V. The subjects are classified in this table according to their colour vision, and the results of the first and second experiments, *a* and *b*, for each subject are shown separately. Each reading is the mean of three ascending

Table 4. *Colour brightnesses in terms of voltage, compared with standard blue at* 250 V.

	Men												Women							
	Normal						Y-G weak		R-G blind				Normal						B weak	
	1		5		8		2		7		9		3		4		10		6	
Colour	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
G	150	164	152	176	160	160	148	138	148	160	200	180	148	152	150	148	156	192	156	156
Y	180	164	168	158	170	184	138	134	148	164	148	154	148	148	146	148	164	160	162	150
R	142	144	170	172	156	168	140	132	154	168	180	156	140	138	136	128	136	132	144	158
W	86	96	92	88	68	94	72	74	98	84	72	80	72	74	88	72	61	86	70	100

Table 5. *Ranges of colour brightnesses abstracted from Table* 4

	Men			Women	
Colour	Normal	Y-G weak	R-G blind	Normal	B weak
Green	150–176	138–148	148–200	148–192	156
Yellow	158–184	134–138	148–164	146–164	150–162
Red	142–172	132–140	154–180	128–140	144–158
White	68– 96	72– 74	72– 98	61– 88	72–100

and three descending series by the limiting method. In every case the separate measurements were very close together, varying by a few volts only, and so they will not be further discussed. Table 5 shows the ranges of brightness matches abstracted from Table 4 so that they are more easily seen. This brightness experiment forms an interesting study of colour vision apart from its relevance to the veiling glare experiment, and I shall pause here to discuss it briefly.

(*b*) *Colour vision of the subjects*

Subjects 1, 5 and 8 were men with normal colour vision and Subjects 3, 4 and 10 were women with normal colour vision.

Subject 2 I have classed as yellow-green weak. His weakness was not discovered until after the experiments were complete, though in private he had suspected some peculiarity

before. Since then he has been examined carefully with a variety of tests. He fails on the Ishihara test, being classified according to that test as 'green-blind'. He also fails on the Stilling tables for red-green blindness, but is able to read the yellow-blue and blue-green tables easily. He does the Holmgren wool test easily, but he chose skeins 80, 82 and 84 wrongly to match skein 102, on one occasion. He does the Edridge-Green bead test easily. He does not make any colour mistakes or confusions in daily life, but thinks that it takes a woman to name greens because there are so many names in use that a man does not have to employ in relation to clothing and so on. In the spectrometer it appears that the spectrum is of normal length, but the colours are deviated towards the red end, blue invading green slightly, green invading yellow to a marked degree and yellow slightly invading red. Other tests besides the colour brightness experiment described here show that yellows and particularly greens are brighter for him than for the normal. The Ilford 'spectrum' yellow filter used in this experiment he calls green, and it was owing to my insisting that it was yellow that his peculiarity was discovered, but he regards it as a less saturated green than the 'spectrum' green filter. The ordinary mixed yellows of daily life, most of which contain a considerable proportion of red, orange yellow-green and even green rays in addition to yellow, do not confuse him. In the Rayleigh Equation he appears to be a 'green anomalous' subject, but in certain ways he is like Houstoun's 'colour different' subjects(4), though much less colour-blind than the 'colour-different' subjects actually described by Houstoun (who, nevertheless, claims that it is unfair to class them as colour-blind). While Houstoun's 'colour different' subjects make mistakes because the colours in common use are not strictly monochromatic, Subject 2 makes mistakes with monochromatic and not with ordinary colours except in the Stilling and Ishihara tests. The details of this subject's colour vision are comparable with details given by Edridge-Green(5) of a subject described by him as 'green-anomalous', and they confirm Edridge-Green's view that an anomalous equation may result when the yellow to be matched in the Rayleigh Equation is more allied to green (or red) than is normal.

Subject 7 is a typical deuteranope, if such can exist. He does make use of the terms 'red' and 'green' in his own way, but admits that they apply to what are, for him, in reality different kinds of yellow. Full-coloured yellows are called 'red', intermediate yellows 'yellow' and pale yellows 'green', though there is no difference of hue between red, orange, yellow and green. It is clear that his colour terminology is an attempt, adopted half-consciously, to adapt himself to the ways in which other people use colour names. By this terminology he is able to reduce his gross mistakes to the minimum. He is readily trapped into gross mistakes under test conditions; but, when a yellow is full coloured there is a considerable probability of it being what people call 'red', and if it is pale coloured then it is likely to be what other people call 'green', and so he often avoids error under ordinary conditions. I cannot find any evidence whatsoever that he sees either red or green as a distinct hue. In the spectrometer he applied colour names thus:

End of spectrum to 6620 A.	6620–5170 A.	5170–5000 A.	5000 A. to end of spectrum
'Doubtful'	'Yellow'	'Green'	'Blue'

Afterwards he admitted that the term 'doubtful' was used because he suspected that this was the kind of yellow which other people call red, and the term 'green' was used where he suspected that the yellow he saw would be called green by ordinary people.

Subject 9 is in many ways similar to Subject 7, except that he has a very marked weakness in yellow and a slight or moderate weakness in blue as well as the red-green weakness. He is confident that he can distinguish red, and slightly less confident about green, and he considers his trouble to be a tendency to use colour names wrongly, saying that he has never learned them successfully. However, his supposed ability to distinguish red and green may be tested very easily. He is asked to match the pink and pale green skeins in the Holmgren wool test and he puts fawns, pinks and greens as matches for both of them. He is then asked whether there are any differences between the colours in the two heaps of fawn, pink and green skeins. He replies that there are differences—that some skeins are reddish and others are green. He is invited to rearrange them to separate these colours, and does so with great difficulty, making two new heaps each containing as many pink as green skeins. Such a subject will constantly glance at the experimenter, almost unconsciously looking for a hint, and it is of vital importance that the experimenter should maintain a 'poker-face' and give absolutely no guide, hint or suggestion.

In the spectrometer test he gave the following results:

End of spectrum to 6600 A.	6600–6100 A.	6100–5000 A.	5000–4200 A.	4200 A. to end of spectrum
'Grey'	'Yellow'	'Yellow becoming paler'	'Touch of blue'	'Blue becoming paler to end'

The spectrum is not shortened, but the red end is colourless. He believes himself to have good colour vision, and views the tests with decided scepticism. The yellow and blue weaknesses were discovered mainly in experiments with rotating disks and in a colorimeter test which there is not space to describe here, but it is easy to observe that he has great difficulty with the blue-green plates in Stilling's tables (XI_1 and XI_2). The green dots look more blue than for normal people and the blue dots look more grey—hence the figures are very difficult for him to read.

Subject 6 has normal red-green and yellow sensitivity, but has a diminished sensitivity to blue, which is apparent in her difficulty with the blue-green plates in Stilling's tables, and can be measured by adequate technique in rotating disk and colorimeter experiments. Difficulty with the blue-green plates in the Stilling test is not, in my opinion, by itself definite evidence of blue weakness, but is suspicious and requires confirmation by as many other tests as possible.

(c) *Discussion*

Tables 3 and 4 should show sharp increases in voltage required by the colour-blind subjects to bring yellow, green and white up to the normal blue level of brightness if the Young-Helmholtz theory were true. Since Subjects 7 and 9 would be classed as 'completely green-blind' on that theory, the green sensation would be considered missing, and green, yellow and white would all be diminished in brightness in proportion to the loss of this sensation, in so far as it is, on that theory, supposed to contribute to make them up. Therefore these colours would have to be brightened in comparison with the match with blue made by the normal person in whom the green sensation is not absent. Similarly with Subject 6, whether, on the Young-Helmholtz theory, we consider her to be slightly 'violet-blind', or consider her weakness in blue to be due to pigmentation of the macula, blue should be of diminished brightness compared with the blue of normal people, and all the other colours should be reduced to match it. With Subject 2, if on

the Young-Helmholtz theory we consider him to be a 'partial deuteranope', which is the only possible explanation of his very unusual colour vision on that theory, then green, yellow and white should be of diminished brightness and should require higher than normal voltages to match the standard blue.

These requirements of the Young-Helmholtz theory are not satisfied by the results of the experiments. Subject 7 makes brightness matches comparable with those of normal subjects. So does Subject 6. Subject 2, far from satisfying the requirements stated, has all the colours if anything brighter than the normal and requires lower voltages to make them match the blue standard. Subject 9 requires green to be brightened, as the theory predicted, but red, in which, on that theory, he is not supposed to be weak (though I fail completely to find any evidence that he is able to see red), also seems to require a little brightening, while white and yellow are relatively unchanged compared with the normal. Subject 10, who has excellent colour vision, and who has been carefully tested by rotating disk and colorimeter tests and by the ordinary tests for colour-blindness, requires green to be almost as much brightened as does Subject 9 who is very colour-blind, and, in general there are as big differences in brightnesses among the normal subjects as between normal and colour-blind, with the exception of the first reading of Subject 9 for green, which was changed to a lower voltage the second time he did the experiment.

These data therefore give no support to the Young-Helmholtz theory, and I find it very difficult to understand how a red-green blind subject, such as Subject 7, can have normal colour and brightness sensitivity to yellow and white, unless we adopt a colour theory on which yellow and white are not necessarily dependent on the integrity of both red and green sensations. I have directed these objections against the Young-Helmholtz theory because it is the most popular theory of colour vision. The other theories all have their difficulties, and it is far from easy to see how the facts of colour vision can be accounted for by a simple theory at all.

IV. THE VEILING GLARE EXPERIMENT

(a) *Two parallel experiments*

In the first place it is necessary to consider how far the second or parallel experiment confirmed the first. Table 6 shows the significant differences between the mean readings in the two experiments arranged according to subject, colour used and 'size' or 'distance'

Table 6. *Statistically significant differences between the mean readings for the first and second experiments, in cm.*

Dashes indicate no significant difference; crosses indicate no reading. Throughout this paper differences are considered significant if more than three times their own standard errors.

	Subject									
	1 m.	2 m.	3 f.	4 f.	5 m.	6 f.	7 m.	8 m.	9 m.	10 f.
Colour					'Distance'					
B	—	—	—	—	—	—	13·0	10·0	15·7	—
Y	—	—	—	—	—	—	—	—	—	—
G	—	—	6·5	—	—	—	—	11·0	—	—
R	—	—	6·0	—	—	—	—	—	—	—
W	—	—	—	×	—	—	—	—	—	—
					'Size'					
B	—	—	3·1	—	6·1	—	×	—	×	—
Y	—	—	7·1	—	—	—	×	—	×	6·4
G	—	4·9	7·4	—	—	6·9	×	—	×	—
R	—	—	4·1	7·6	—	—	×	—	×	—
W	—	3·0	4·6	7·3	—	—	×	—	×	4·4

method employed. For the 'distance' method in all there were six significant differences out of a possible 49. For the 'size' method there were 13 significant differences out of a possible 40. This gives a 2×2 table for which, assuming that chance would have given as many significant as insignificant differences by both methods for the two experiments, χ^2 is 32·9. The probability of getting such a small number of differences between the experiments by chance alone is negligible, and we may assume confidently that there is a very strong influence at work making the two experiments alike. In other words, the second experiment gives the same result as the first. In most of the remaining calculations, therefore, the results of the two experiments have been pooled and treated as if obtained from a single experiment.

It will be noticed, however, that Subject 3 had 7/10 significant differences, while no other subject had more than 2/10 or 1/5. This is a very strong indication that she was less reliable on a repetition of the test than any other subject. When coupled with the knowledge, obtained from class work in the Psychological Laboratory, that she had a very low perseveration in the '*s*' test and rapidly fluctuating after-sensations, high fluency of ideas in the ink-blots test and was on general grounds considered a person of somewhat hypo-manic disposition, this result is very interesting. It may be concluded that the effect of a repetition of the experiment is largely personal: most people are not affected by it, but certain persons may be affected to a very marked extent.

(*b*) '*Size*' *and* '*distance*' *methods*

It is now necessary to consider the proportions of significant and insignificant differences between the mean readings for the 'distance' and 'size' methods in the pooled results of the two experiments. These are shown in Table 7. It will be seen that there are 18 significant differences and 21 not significant. From this it may be concluded that in general the 'size' and 'distance' methods produce the same results as often as not. It will be noticed, however, that Subjects 5 and 8 have all their differences significant,

Table 7. *Significant differences between mean readings in cm. by 'size' and 'distance' methods*

A dash indicates no significant difference; a cross indicates no reading.

	Subject									
Colour	1 m.	2 m.	3 f.	4 f.	5 m.	6 f.	7 m.	8 m.	9 m.	10 f.
B	4·5	—	2·4	—	10·4	—	×	11·1	×	—
Y	—	3·2	—	—	10·9	—	×	11·7	×	—
G	4·4	—	—	—	9·4	—	×	14·7	×	—
R	6·0	4·2	—	—	11·8	—	×	10·8	×	—
W	4·5	3·4	—	×	12·2	—	×	11·4	×	—

Subject 1 has 4/5, Subject 2 has 3/5, Subject 3 has 1/5 significant, and the remaining subjects have no significant differences. Subjects 1, 2 and 5 were more experienced in this work than the others. Hence it would appear that the differential effect of the 'size' and 'distance' methods is an individual peculiarity, but, since Subject 8, all of whose differences were significant, was quite inexperienced, it does not appear to depend on practice.

The problem of the differential effect of the 'size' and 'distance' methods may be approached in other ways. In Table 6 it was shown that by the 'distance' method 6/49 significant differences were found between the parallel experiments, while by the 'size' methods 13/40 such differences were significant. We may calculate χ^2 for these frequencies

on the assumption that no differential effect of the two methods would result in as many significant differences between the two experiments by the 'size' as by the 'distance' method. Thus we wish to find out whether 40 divided in the ratio of 13/27 differs significantly from 49 divided in the ratio of 6/43. χ^2 for these differences is 14·83, and so they are decidedly significant. We must conclude that although in general the 'size' and 'distance' methods are alike in effect, the 'size' method is decidedly less consistent with itself than the 'distance' method.

The third way of approaching the same problem is by considering the proportions of mean readings which differ significantly from zero in the pooled results of the two experiments. These are shown in Table 8. They are pooled for all subjects. The frequencies

Table 8. *Numbers of mean readings significantly and not significantly differing from zero in the 'size' and 'distance' methods for all five colours shown separately*

A mean reading was considered significant if more than three times its own standard error.

Colour		Blue	Yellow	Green	Red	White	Totals
'Distance'	Significant	3	5	7	6	5	26
	Insignificant	7	5	3	4	4	23
'Size'	Significant	3	3	5	3	5	19
	Insignificant	5	5	3	5	3	21

in the column of totals might easily have been obtained by chance, and it will be concluded that there is no indication that in general the 'size' method produces a measurable distortion of the true position of the variable with respect to the standard more often than does the 'distance' method, under the conditions of the experiment.

(c) *Right and left position of the standard*

The position of the standard disk often has a marked effect on the results of experiments such as this. By the 'distance' methods there were 26/49 significant differences between the mean readings for the variable when the standard was to the right and when it was to the left. By the 'size' method there were 26/40 such differences. χ^2 for this 2×2 table is about 3·8, and the probability, with two degrees of freedom, is on the

Table 9. *Significant differences, in cm., between mean readings with standard right and standard left (space error)*

A dash indicates no significant difference. A cross indicates no reading available.

	Subject									
	1 m.	2 m.	3 f.	4 f.	5 m.	6 f.	7 m.	8 m.	9 m.	10 f.
Colour					'Distance'					
B	—	—	2·3	10·8	—	6·5	—	—	—	27·7
Y	4·4	—	—	18·1	—	—	—	7·5	10·2	16·1
G	—	—	5·8	13·3	—	4·4	13·5	—	14·8	14·8
R	4·1	—	—	26·8	—	3·6	17·8	9·8	4·9	12·9
W	—	—	4·5	×	—	—	11·3	—	13·0	10·0
					'Size'					
B	5·3	6·6	—	19·5	—	5·3	×	26·3	×	10·1
Y	6·5	5·0	5·7	—	—	11·7	×	24·5	×	—
G	7·1	4·3	—	8·6	—	—	×	28·5	×	6·9
R	8·1	4·9	—	7·9	—	18·5	×	17·8	×	6·3
W	4·6	1·6	—	—	—	7·6	×	22·7	×	4·7

0·3 level, hence there is no suspicion that the 'size' method exaggerates the space error. Table 9 shows these results in detail. Subject 5 is unaffected by the space error. Subject 2 alone is unaffected by the space error in the 'distance' method and affected by it on

every opportunity in the 'size' method. Subject 10 is affected by the space error on every possible occasion but one, and the other subjects fall between these extremes. The colours produce space errors with almost equal readiness, thus: Blue, 10; Yellow, 10; Green, 11; Red, 13; White, 9. Subject 10 has the largest average space error for the 'distance' method, and Subject 8 has the largest space error for the 'size' method. Like other aspects of the experiment, the space error shows in general that the effect of the differential veiling glare is much dependent on individual difference tendencies of the subjects tested.

(*d*) *Comparison of colours*

If all the mean readings for the five colours taken separately in the pooled results of the two experiments are compared, taking them in groups according to the subject being tested, only 12 significant differences out of a possible 96 are found by the 'distance' method and only 5 out of a possible 80 by the 'size' method. These results are shown in Table 10. On the whole, the total of no more than 17 significant out of 176 possible

Table 10. *Significant differences between mean readings for different colours, showing which colour gave greater 'error' from standard, and the subject and method concerned*

Colours compared	Subject's number and sex	Method
Blue < Yellow	2 m.	Distance
Blue < Green	5 m.	Distance
Blue > White	3 f.	Distance
Blue < White	1 m.	Distance
Blue < White	5 m.	Distance
Blue < White	2 m.	Size
Blue < White	5 m.	Size
Blue < White	6 f.	Size
Yellow > White	5 m.	Distance
Yellow < White	1 m.	Size
Green > Red	5 m.	Distance
Green > White	1 m.	Distance
Green > White	2 m.	Distance
Green < White	1 m.	Distance
Red > White	2 m.	Distance
Red < White	5 m.	Distance
Red < White	2 m.	Size

differences is a very strong indication that in general colour has no effect. The probability of getting such a result by chance is very high and there is no reason to suppose that colour difference produced any measurable differences in the appearance of the disks. It is interesting, however, that there should be 12/96 significant differences between colours by the 'distance' and only 5/80 by the 'size' method. If we assume that by chance one method should have produced as many differences as the other, then χ^2 for this frequency table is 6·4, and the probability almost as low as 0·01. This strongly suggests that the colours produced more difference by the 'distance' than by the 'size' method.

It should also be noticed that 14/17 significant differences due to colour were between another colour and white. This is an indication that, when differences due to colour did occur, which was seldom, the contrast between white and other colours was more important than that between the other colours among themselves. However, of these 14 significant differences which concerned white, 9 showed more 'error' between variable and standard disk with white than with another colour, while only 5 of the differences favoured white. This certainly gives a suspicion that white is at a disadvantage, but the difference is not sufficient for any conclusion to be drawn. Of the 9 differences which favoured another colour than white, 5 favoured blue, 2 red, 1 green and 1 yellow.

The effect of colour, when it does occur, however, seems to be a personal matter, because, of the 17 significant differences obtained, 6 fell to Subject 5, 5 to Subject 2, 4 to Subject 1, and the remaining 2 fell to Subjects 3 and 6. The colour effect was therefore monopolized by Subjects 5, 2 and 1, and might be due to expertness in doing the experiment, because they were more experienced observers in this work than any of the other seven.

Another interesting way of studying the effect of colour here is to compile a table showing the proportions of significant differences between the mean readings in the three principal conditions controlled by the experiment classified according to colour. This shows the possible effect of colour upon the other conditions which were open to change, and these figures, pooled for all subjects, are shown in Table 11. It will be seen that the proportions of significant differences in each perpendicular column show very little variation corresponding to the colour used. It is seen that no colour had a tendency to monopolize the differences due to other factors or conditions, while it was clear from figures quoted above that certain subjects did tend to monopolize the differences due to colour.

Table 11

	Proportions of significant differences between		
Colour	1st and 2nd experiments	'Size and' 'distance' methods	Standard right and standard left
Blue	5/18	4/8	10/18
Yellow	2/18	3/8	10/18
Green	5/18	3/8	11/18
Red	3/18	4/8	13/18
White	4/17	4/7	8/17

(e) *Sex differences*

In the comparison between the first and second experiments shown in Table 6, the majority of significant differences were gained by Subject 3, who is a woman. The other women, namely Subjects 4, 6 and 10, were not inconsistent, while it was known from other tests that Subject 3 had a slight hypo-manic tendency which probably accounts for her unreliability in the experiments.

From Table 7 it is seen that the three men with normal colour vision obtained 14/15 significant differences between the mean readings by the 'size' and 'distance' methods, while the three women with normal colour vision gained 1/14 such differences. If we include the man and woman who had slight colour defects, Subjects 2 and 6, these proportions become 17/20 for men and 1/19 for women. This is a striking difference, especially since it includes one man, Subject 8, who was not expert in the experiment, and it shows that the men were consistently affected by the 'size-distance' difference, while in the women's readings any such contrast was obliterated by chance errors.

If we turn to the numbers of mean readings which differ significantly from zero, shown

Table 12

		Women	Men
'Distance'	Significant	10	16
	Insignificant	9	14
'Size'	Significant	7	12
	Insignificant	13	8

in Table 8, and re-count them to find how many were made by men and how many by women, we may construct Table 12. This distribution of frequencies might easily have

been obtained by chance, and it does not suggest any difference between men and women in the accuracy of their estimates of size or distance under the conditions of the experiment.

As far as colour is concerned, all the significant differences due to colour except two were obtained by men, as shown in Table 12, but the three men concerned were all expert observers in this kind of experiment, and this is more likely to be the explanation than is the sex difference.

(*f*) *Differences of colour vision*

The two red-green blind men, Subjects 7 and 9, taken together, obtained 1/10 mean readings significantly different from zero, taking the five colours separately. The two colour-weak subjects obtained 11/20 significant mean readings, and the normal subjects obtained 26/59. Thus, while the proportion of mean readings significantly different from zero is about 1/2 for normal and colour-weak subjects, it is only 1/10 for the colour-blind. This suggests that the colour-blind were much less consistently affected by the veiling glare than the normal and colour-weak. It is also interesting to find that both of the colour-blind men were quite unable to do the experiment by the 'size' method, since the variable disk continued to look the same size as the standard to them whatever the difference in distance (within the limits of the apparatus). Subject 2, who is yellow-green weak, also had much difficulty with the 'size' method, but taught himself to do it by repeated efforts. Unless we had a reasonably large random sample of colour-blind and colour-weak subjects to test, it would not be possible to draw any conclusion from such results.

V. Summary and conclusions

(*a*) The aim of this experiment was to try to find out whether illumination with any of the colours red, yellow, green, blue or white might be better for judgement of size and distance of objects seen through veiling glare in binocular vision.

(*b*) The apparatus used was essentially as described in another paper(2) with modifications explained at the appropriate places. The coloured illumination was produced by 'daylight' lamps together with the Ilford Monochromatic colour filters (602, 604, 606 and 608), except the white light, which was the colour of the illumination from 100 W. 'daylight lamps'. The limiting method was used. The brightnesses of the colours were determined for each subject as compared with the blue which was taken as the standard, and they were used at the appropriate brightnesses for each subject.

(*c*) There were ten subjects, of whom two were red-green blind men (deuteranopes), one a yellow-green weak man, one a blue-weak woman and the remainder were three men and three women with normal colour vision.

(*d*) The colour brightness experiment showed that relative brightnesses of colours vary considerably among normal subjects, and the brightnesses chosen by the colour-weak and colour-blind did not differ from the normal in accordance with what would be expected on the Young-Helmholtz theory of colour vision. The red-green blind subjects were both insensitive to red and to green as hues distinct from yellow, and could not be classed as 'green-blind' although they were deuteranopes in the sense that the red end of the spectrum was of normal length. They are 'red-green' blind. Other less important points about colour vision are mentioned in the paper.

(*e*) The whole experiment was divided into two parallel halves carried out with an interval of at least 3 weeks between them. These two halves confirmed each other and establish the reliability of the whole experiment. The subject whose reliability was least was known to be slightly hypo-manic.

(*f*) The 'size' and 'distance' methods, described in the article, did not produce in general different results, but the significant differences between the methods were monopolized by four subjects, so that liability to be consistently affected by the difference between these methods of perception would seem to be an individual difference tendency.

(*g*) The 'space error', due to the right or left position of the standard compared with the variable disk, is prominent, but as frequent when the 'size' method is used as when the 'distance' method; and in different coloured illuminations. But it varies considerably from one subject to another, and is another form of individual difference.

(*h*) The colours had almost no consistent and measurable effect, but in the few cases, where an effect due to colour was found, it seemed to be more frequent when the 'distance' method was used than when the 'size' method was used. There was a suspicion that, where colour differences were found, blue veiling glare may have produced least distortion of the apparent size or position of the test objects, while most distortion may have been produced by white glare. In the few cases where colour differences were found it appeared that they tended to be monopolized by special individuals and must be regarded as due in part to individual differences.

(*i*) The only clear difference between men and women was that the men subjects were consistently affected by the difference between the 'size' and 'distance' methods, whereas this difference was blurred by chance errors for the women.

(*j*) The red-green blind subjects were both unable to do the experiment by the 'size' method, and had a larger number of mean readings not differing significantly from zero than either the colour-weak or the normal subjects.

(*k*) The most general conclusion is that the effect of the differential veiling glare is due first and foremost to individual differences between subjects. Thus, whichever objective changes we take, whether of colour, of the position of the variable compared with the standard, or the simple repetition of the experiment, or even if we take the subjective change due to the method of perception, the outstanding differences produced by these changes are peculiar to certain individuals who appear to be sensitive to those changes, and are not produced for all subjects in general.

The order of magnitude of influence of the main variable conditions studied in the experiment appears to be as follows: 1, individual differences between subjects; 2, 'space error'; 3, 'size' or 'distance' method of perception; 4, repetition of the same experiment; 5, colour of veiling glare.

I am greatly indebted to Prof. G. W. O. Howe for lending apparatus from the Electrical Engineering Department of Glasgow University; to Dr Bernard Hague and Dr A. J. Small of the same Department for their advice about the arrangement of the electrical apparatus; to Dr M. Collins and Dr Boris Semeonoff for their advice about the measurement of colour brightnesses; to Mr Joseph F. Simpson, Laboratory Attendant of the Psychology Department, for frequent help with the experiments and for calculating the means and standard errors; and to the subjects of the experiment for their help.

REFERENCES

(1) Martin, T. M. & Pickford, R. W. (1938). "The effects of veiling glare on apparent size and distance." *Brit. J. Psychol.* xxix. 91–103.
(2) Pickford, R. W. (1943). "Some effects of veiling glare in binocular vision." *Brit. J. Psychol.* xxxiii, 150–161.
(3) Ilford Colour Filters. London: Messrs Ilford Limited, Ilford.
(4) Houstoun, R. A. (1932). *Vision and Colour Vision*, pp. 213–15. London: Longmans, Green and Co.
(5) Edridge-Green, F. W. (1920). *The Physiology of Vision*, Ch. xxiv, pp. 221–2 and 225. London: G. Bell and Sons, Ltd.

(*Manuscript received* 2 *August* 1943)

NOTICE TO MEMBERS OF THE MIDLAND BRANCH OF THE BRITISH PSYCHOLOGICAL SOCIETY

The Midland Branch of the British Psychological Society is to resume occasional meetings. As the membership of the branch is at present very uncertain, the notices of the first meeting are being sent only to those within a range of about 25 miles of Birmingham. Will any members living outside this area who wish to have notices of future meetings please send their names and addresses to the Chairman, Professor C. W. VALENTINE, The University, Edmund Street, Birmingham?

THE APPLICABILITY OF KARL PEARSON'S SELECTION FORMULAE IN FOLLOW-UP EXPERIMENTS

By GODFREY H. THOMSON

When schoolchildren are followed up in their secondary school careers they form of course only a sample of the whole school population, and not a normal sample but the upper tail of a distribution. The correlations between their different tests at entry and their performances later in secondary schools are lowered by this selection, and it is natural to wish to estimate what these correlations would have been could the whole year group have been followed up. The correct way of doing this is by the use of Karl Pearson's selection formulae, preferably in Aitken's matrix formulation, since that facilitates calculation (see Emmett, 1942).

It has, however, been urged that this procedure is incorrect because the distribution of the sample is not normal. It is frequently said that for Pearson's selection formulae to be applicable the distributions both in population and sample have to be normal. This, however, is not so. The necessary and sufficient conditions have recently been set out by Mr D. N. Lawley, and the purpose of the present short note is to call attention in psychological circles to his paper. These conditions are: (*a*) that the regressions must be linear, and (*b*) the matrix of partial variances and covariances of the non-selected variables must be independent of the values fixed, by selection, for the matrix of variances and covariances of the selected variables. In the case of two variables, if these conditions are fulfilled in the population, they will remain fulfilled in a tail or slab of the population distribution.

I have before me a large number of calculations in which Mr W. G. Emmett, at present absent on national service, tested Pearson's formulae on truncated samples from a Northumberland complete age group in which the complete correlations were known. He found substantial agreement between the estimates and the known true values.

Recently I have had data from Leicester through my hands which permit of the same calculation and check. Of 1390 boys, 245 went into secondary, 214 into intermediate, and 931 into senior schools. A certain correlation coefficient was known to have the value 0·926 in the whole population of 1390. The actual values in the above three samples were 0·841, 0·671 and 0·881, respectively. Estimated by Karl Pearson's formulae the population values found were 0·912, 0·916 and 0·932, respectively. The case of the intermediate school sample is the most relevant here, for the selection was solely on a test and the cutting off quite sharp. In the secondary school sample this is not so definitely the case, as fee-paying pupils with lower scores were present. Similar results were found for the 1189 girls.

REFERENCES

Emmett, W. G. (1942). *An Inquiry into the Prediction of Secondary School Success.* University of London Press.

Lawley, D. N. (1943). "A Note on Karl Pearson's selection formulae." *Proc. Roy. Soc. Edinb.* (read July 1943. In the Press).

(*Manuscript received 7 October* 1943)

PUBLICATIONS RECENTLY RECEIVED

Habit and Heritage. By FREDERIC WOOD JONES. London: Kegan Paul, Trench, Trubner and Co., Ltd. 1943. Pp. 100. 5*s.* net.

Prof. Wood Jones is concerned with the influence on contemporary life and thought of an unthinking acceptance of the theories of the 'survival of the fittest' and the non-inheritance of acquired characteristics. The relevance of a belief in the survival of the fittest to Nazi doctrine and practice is obvious. And the logical conclusion from the theories of Darwin and Weismann is that the effect of character training and cultural improvement can at best be superficial and transitory; every individual must begin again at the beginning.

After a masterly survey of the inconsistencies and contradictions inherent in Weismannism, Prof. Wood Jones examines a series of cases in which the only reasonable explanation of the phenomena observed appears to be the Lamarckian one. The natural selection of random germinal variations of such characteristics seems as unlikely as the behaviourist supposition that all the books in the British Museum *might* be written by a number of apes tapping at random on typewriters. Of these phenomena perhaps the most interesting are the different modifications in the facets of the tibia and astralagus which exist in the squatting Oriental and the squatting Australian aborigine; and the modifications of hair disposal occurring in various animals in accordance with 'grooming' habits. Incidentally, Prof. Wood Jones points out that the acquired characteristics which are likely to be inherited are those which come into being in response to the action of use or environment during many successive generations. Thus it is comprehensible that the results of experiments such as McDougall's should be inconclusive. The only reliable evidence is that obtained from prolonged 'natural' experiments such as those mentioned.

The psychologist may not be in the position to test the accuracy of Prof. Wood Jones's observations and conclusions, though he must admire the clarity of their exposition. And he must welcome the possibility of such a line of attack upon the dreary conclusions resulting from the Darwinian and Weismann theories, and their possibly repressive influence on the amelioration of social conditions.

Psychology for the Fighting Man. NATIONAL RESEARCH COUNCIL. Washington, U.S.A.: Infantry Journal. Penguin Books. 1943. Pp. 456. 25c.

This book is "prepared for the fighting man himself by a committee of the National Research Council with the Collaboration of Science Service as a contribution to the War Effort". There is a very long list of collaborators which includes nearly all the distinguished names in current American psychology. Responsibility for the final form of the book is assumed by Prof. E. G. Boring and M. Van de Water.

It can be said at once that this is an extremely well-thought-out and well-executed book. It covers a very wide field, discussing general problems of warfare from the point of view of the ordinary soldier; giving a most excellent account of the importance of man's sensory equipment; judiciously covering problems of selection and training; and including some most interesting discussions of such questions as Leadership, Mobs and Panic, Rumour, Propaganda and the like.

Occasionally the ordinary reader may get a considerable jolt, as on p. 12, where he is informed that "the Army has a perpetual problem of psychological logistics". But in general the language is simple, the explanation very plain and clear, the style interesting and the illustrations good. It would be a very great service to the British Army if, revised in places so as to make it more suitable for the general run of British soldiers, the book could be published immediately in this country and very widely circulated.

Conscience and Society. By RANYARD WEST. London: Methuen and Co., Ltd. 1942. Pp. 260. 15*s.* net.

The central theme of this book consists of the theory, elaborated from a recent paper by Dr Ranyard West in this *Journal*, that man requires the support given by the enforcement of the law for controlling the evil-doer in his own unconscious mind, although he may rationalize it as the control of the evil-doer in others. No one can be an impartial judge in his own case. Therefore a series of external rules and regulations are necessary. This is now recognized in the relations between individuals, but it has not yet been accepted as between the nation states. For the future peace of the world it is necessary that these states should make a voluntary abnegation of their sovereignty, but in doing so, they must set up a judicial body with supernational powers which shall determine and enforce international law. Hitherto the latter has been merely in the nature of a series of promises broken whenever it is convenient. Unless the nation states know that this law can and will be enforced against them, each one will continue to 'project' the origin of any breakage of international law upon some other.

Dr Ranyard West begins his book with a discussion of the theories of government of Hobbes, Locke and Rousseau, and of other philosophers and jurists. He then relates these to what is known of the nature of the unconscious mind. He criticizes the Freudian theory, modifying it along the lines suggested by Ian Suttie and postulating two main instinctive tendencies, the self-assertive and the social. He illustrates the conflict between these by the study of case histories of obsessionals, but concludes that, except

in the obsessional (who may have far too much influence on the course of international relationships), it is the social instinctive tendency which is the stronger in the long run. Nevertheless, it must be reinforced by the external sanctions of the law; thus men create and enforce laws for that purpose.

The early part of the book is perhaps rather unnecessarily prolonged and involved, and the reader is unable to see clearly its bearing on the main thesis until he reaches the second and third parts of the book. But in these the argument is set forth most convincingly. Alas that the nation groups and their governments, though realizing they have social obligations towards their members, are still so ready to believe their fulfilment lies in increasing the sovereign power of the group rather than in abnegating it in favour of the world state. Dr Ranyard West shows only too clearly that mere expressions of good will without the readiness to accept externally enforced law will lead nowhere.

Behavior and Neurosis. By JULES H. MASSERMAN. Chicago: University of Chicago Press. Pp. xv + 269. 1943.

This book presents a most interesting collection of data on the experimental study of animal behaviour, particularly in situations involving frustration or conflict of drives. The reader who wishes for an abstract of the relevant literature should go first to Part II; and in Part I, chapter III, he will find an excellent critique of the hypothalamic theory based on a study of the literature and on some interesting experiments of the author's. The main thesis of the book is, however, based upon the author's experiments on the formation of experimental neuroses in cats, described in Part I, chapters II and IV. The cats were first conditioned in the feeding responses, to various sensory stimuli; and a fear-producing stimulus (an 'air blast', in general) was then introduced simultaneously with these stimuli. Typical neurotic behaviour supervened, e.g. refusal to eat even when almost starving, 'phobic' responses to the feeding stimuli, compulsive hiding and escape reactions, etc. This neurotic behaviour often persisted over long periods of time, but was sometimes diminished by reassurance and petting, by forcible feeding, by the social example of other non-neurotic cats, and, most interestingly, by 'working through' their conflict of fear and hunger through partial manipulative control of the experimental situation.

On the basis of these observations, the author endeavours to effect a rapprochement with the psychoanalytic theory of the origin of neurosis, in the shape of a behaviouristic or 'psychobiologic' approach. It does appear that there may be some similarity between the symptoms and psychotherapeutic treatment of experimental neurosis in cats, and of the relatively simple forms of neurotic behaviour in man produced by acutely disturbing emotional traumata, e.g. in airmen who have crashed—though even then the psychotherapeutic methods in the two cases are analogous rather than fundamentally the same. For instance, the 'petting' and 'reassurance' of the cat only very superficially resembles the formation of the 'transference' in psychoanalysis. It is not difficult to see why the two approaches must diverge. We can have no direct knowledge of the nature of consciousness or of the unconscious mind and its functions in animals; whereas psychoanalytic theory and method, shorn of these functions, is like Hamlet without the Prince of Denmark.

Thus the reader is recommended to study the animal data for their own intrinsic interest, without straining to achieve any 'psychobiologic' theory that links them with neurosis in man.

Bird Display. By E. A. ARMSTRONG. Cambridge University Press. 1942. Pp. xvi + 381. 21*s*.

Mr Armstrong has very correctly called his book 'An Introduction to the Study of Bird Psychology', and it may be said at once that it is an introduction written with unusual clarity and charm, beautifully illustrated, and offering an alluring prospect to the reader who wishes to proceed further with his studies. Its scheme is general rather than monographic, that is to say, its style is reminiscent of those anthropological treatises which range all over the world for their illustrative material. The general theme is the part played in the lives of many varieties of birds and of bird communities of more or less regularized ceremonial. In the first ten chapters the relevant facts are exceedingly well selected and described. Then follow three chapters, of particular interest to the psychologist—whether he has a special interest in bird life does not matter—dealing with the evolution and function of ceremonial in birds and with the social hierarchy which the ceremonies have helped to develop. The suggestion that the growth of ceremonial may be a protection against the persistence of troublesome pugnacity is particularly worth pursuing. The last six chapters deal in a similar manner with Display proper, and these are followed by a very valuable Bibliography and an Index which is arranged with more than usual care.

People who write about the behaviour of birds and animals frequently adopt one or the other of two extreme views. Everything is explained on rather mechanical principles of the combination of innumerable completely determined small units of reaction into masses which are determined essentially in the same manner; or the complex conduct is treated as the true unit, analysis into elements, or parts, is opposed, and the guiding idea in interpretation is that of a dynamic integration achieved in the interests of some generalized purpose. Mr Armstrong has made a notable effort to bring these two views more closely together. He has done the task so well that both bird lover and psychologist—even when the latter is not also the former—can read with equal pleasure and profit.

Philosophical Essays in Honour of Edgar Arthur Singer, Jnr. Edited by F. P. Clarke and M. C. Nahm. Philadelphia: University of Pennsylvania Press (London: Humphrey Milford). 1942. Pp. x+377. 21*s.* 6*d.*

Nine essays are included under the general heading of *Methodology and Science*; three under *Ethics and Religion*; four under *Aesthetics*; five under *History*; and finally there is a Bibliography of the writings of Prof. Singer.

Although many of the essays contain psychological material, only three of them deal specifically, and in a technical manner, with psychological topics. These are: *The Principle of Associative Learning*, by Edwin R. Guthrie; *The Concept of Volition in Experimental Psychology*, by Francis W. Irwin; and *The Experience Theory of the Social Attitudes*, by Malcolm G. Preston. All three are interesting. The first maintains that a proper understanding of the basic mechanism of association will show that most of the current criticisms, by Gestalt psychologists and others, are beside the point. The second passes in review most of the classical experiments on volition, urges that their findings are largely a consequence of the restricted experimental situations which have been used, and suggests a more comprehensive approach. By far the most interesting and original is Dr Preston's study of social attitudes. Based to a considerable extent upon recent memory experimentation, the essay shows how social attitudes are dynamically determined up to the moment of their expression and are not normally conditioned once for all within whatever framework first produced them. Hence there is often a large discrepancy between assessments of attitudes obtained from questionnaires, and actual expressions of such attitudes in the same population induced by real social situations. Further, it is very neatly shown that frequency of opportunity to adopt social attitudes is not, by itself, a very potent determinant of the attitudes most firmly established. It is much to be hoped that Dr Preston will develop, expand and illustrate his methods and his views in a separate publication.

Narco-analysis. By J. Stephen Horsley. Oxford University Press (London: Humphrey Milford). 1943. Pp. vii+134. 8*s.* 6*d.* net.

Dr Horsley, it appears, was the first to make systematic use of the drowsiness produced by the intravenous injection of barbiturate drugs for the diagnosis and treatment of mental states. The use of the method, which has been facilitated by the production of safe, quickly acting and evanescent drugs, has become frequent during the last ten years and is now advocated by many psychiatrists for the treatment of battle neurosis.

Pentothal and sodium amytal are the favourite drugs. Some psychiatrists prefer to continue the slow injection until the patient falls asleep, and question him as he wakens; others stop the injection before he sleeps. Under the influence of the drug a normal person has usually a sense of well-being and serenity and, as in alcohol intoxication, tends to talk garrulously of trivial or intimate affairs, either spontaneously or in response to questions. He is more suggestible than when he is awake. His speech may be thick, he may be somewhat confused, and subsequent memory of what he has said or done may be incomplete Patients may reveal information of importance which was withheld in the waking state. Some patients with a battle neurosis give a vivid account of battle scenes or act through a scene with intense emotional expression and appropriate motor activity. The psychiatrist listens with sympathy, prompts, suggests, reassures, propounds and persuades. Many patients are better after the injection, which can be repeated; anxiety is relieved, hysterical symptoms removed or memory restored.

Much of the interest of the method is in the mechanism by which is brought about the improvement which undoubtedly follows the injection in many cases. It is at least in part due to the sedation, but some psychiatrists maintain that of greatest importance is the abreaction, that is, the expression and therefore discharge of repressed or pent-up emotions, the intervention of the psychiatrist being secondary. On the other hand, the author believes that the drug, acting by a temporary loosening of psychic tension, is a device for establishing hypnotic rapport and circumventing the resistances which obstruct analysis in the waking state; and that abreaction is only of value by giving opportunity to the psychiatrist to effect the resynthesis of the dissociated personality.

The introduction of the method might have been the occasion for a number of fresh observations relevant to the discussion of abreaction, dissociation and the role of the psychiatrist, but the author makes few references to his own observations during treatment and supports his conclusions by staging a debate in which Freud, Jung, McDougall and Dr William Brown are the protagonists. Had he preferred experiment to discourse—which is on familiar lines—the book might have deserved recommendation to a wider circle of readers than practising psychiatrists. They can find a more concise reference in the journals.

D. R. D.

Psychiatry in Medical Education. By FRANKLIN G. EBAUGH and CHARLES A. RHYMER. New York: The Commonwealth Fund (London: Humphrey Milford). 1942. Pp. xxiv + 619. 20*s.* net.

Although the exact details of the various American training courses for psychiatrists are of no great importance to the English psychologist, yet the latter may find a good deal in this book which is of interest to him, which he may compare with what he knows of psychological and psychiatric training in this country. It appears that a course of psychiatric training covering four years is recommended—two pre-clinical and two clinical—to run concurrently with the student's other medical studies. Academic psychology as it is taught at present is considered to be too divorced from the needs of the medical student to be suitable for the pre-medical curriculum. In the first years of medical training, a course on normal psychology is recommended, and particularly a course of the 'psychobiology' designed by Adolf Meyer, which seeks to relate the study of individual mental processes to somatic functions and to social and environmental factors. Some psychobiological courses are orientated about the 'personality study'—a fearsome questionnaire to be answered in great detail by each student about the most intimate aspects of his previous history and present feelings, attitudes, desires, etc. This seems to have been found successful by several American medical schools, but it would not go down well in this country.

In the second year of training, a course of abnormal psychology is given. But although it is stressed that such a course should "emphasize dynamic psychopathology rather than symptomatology", should give the student an understanding of the processes that lie behind maladjustment, and should not be concerned with clinical diagnosis as such, yet it is noticeable that in most of the courses actually described, abnormal forms of behaviour are grouped according to type of symptom; and the study of the general causes of maladjustment and any theory of the functions of the unconscious mind are conspicuous by their absence. This may, of course, be the best method of training psychiatrists; but in that case there seems to be little gained by separating the pre-clinical treatment of abnormal psychology from the subsequent two-year course of clinical study, particularly as the latter is devoted far more to diagnosis than to treatment. Psychoanalysis is discussed briefly and very tentatively recommended as an option, but no other form of analytical therapy is considered. No direct therapy of children, and of all the valuable data gained from it, seems to be studied; 'child psychiatry' consists of diagnosis, largely in environmental terms, and of training in 'mental hygiene'.

The psychologist will therefore deduce, and may deplore, the fact that psychology does not play any very important part in the training or practice of psychiatrists in America. The authors of this very thorough and detailed study make many valuable suggestions for improving the courses of training. But their ideas are unfortunately somewhat swamped by the excessive detail of the description they give of the courses now in operation. A briefer study of their ideas and recommendations, and the reasons for these, would be interesting. So also would a parallel study for this country.

The Natural Development of the Child. By AGATHA H. BOWLEY. 2nd edition. Edinburgh: E. and S. Livingstone. 1943. Pp. xvi + 184; 84 photographs. 8*s.* 6*d.* net.

Dr Bowley is to be congratulated on the publication of the second edition of her book. There is no doubt that it is admirably suited, and must be thoroughly recommended, for the needs of students of child psychology—for parents, intending teachers, workers in nursery schools. The child's life is clearly and simply studied in four main stages: infancy, the pre-school and middle periods, and adolescence. But Dr Bowley is careful to include a straightforward dynamic interpretation together with her description of characteristic behaviour, so that the reader can trace the continuous development through these stages of the child's understanding of and reaction to his environment. At each stage a picture of normal development is followed by a discussion of characteristic difficulties, their understanding and treatment. Many concrete examples are given, and these, together with the pleasant photographs, vividly demonstrate the descriptions of behaviour.

Of necessity the author has avoided the more difficult psychological theories concerning the underlying basis of the child's attitudes, desires and reactions. But the psychological student can proceed to these by means of the 'Suggestions for Further Reading' given at the end of each chapter. The chapter on 'Children and the War', to which further material has been added in the second edition, seems a little superficial and scrappy. One must conclude that we are still too near the event to understand or gauge at all fully the real effects of war conditions on children.

The Life of Childhood: A Contribution to Analytical Psychology. By MICHAEL FORDHAM. London: Kegan Paul, Trench, Trubner and Co. Ltd. 1944. Pp. viii + 154. 15*s.* net.

To all those interested in the Jungian theory, this book will be of the greatest value and importance, since it gives a very definite idea of how that theory can be applied practically, not only to the psychotherapy of children, but also in understanding their general development. The first part of the book deals with the life of the child in infancy, in family life and in school, and endeavours to show how he

gradually becomes more fully conscious of himself through the experience of the 'archetypes' (the mythological symbols of the 'collective unconscious'), and through the realization that they are a function of his own unconscious and do not constitute the objective reality of his parents. Moreover, he has to learn to establish his best attitude (introvert or extravert) and function (thinking, sensing, feeling or intuition), without altogether suppressing the inferior ones. In the second part of the book, Dr Fordham gives more detailed examples of the characteristic behaviour and phantasies of children as shown in their dreams, their play, and the pictures they draw (the latter are illustrated). Finally he deals briefly with the treatment of maladjusted children—too briefly to be very comprehensible, but as he says, it is not possible for anyone to understand a great deal about psychotherapy without doing it oneself; its methods cannot be written down in black and white in a textbook. But it is interesting to note that, important as he considers the parallel treatment of the parents, he does think it possible to treat the child *as himself* and not as a mere adjunct of his parents.

Those who find the Jungian theory a difficult one will still feel that they are asked to take on trust a great deal of theory—and of practical application—which is very highly speculative. Dr Fordham is a clearer and more persuasive exponent than most Jungians, but even he cannot altogether convince the uninitiated.

Infants Without Families. By DOROTHY BURLINGHAM and ANNA FREUD. London: George Allen and Unwin, Ltd. 1944. Pp. 108. 3*s.* 6*d.* net, paper; 5*s.* net, cloth.

This publication is based upon a further study of the children living in the Hampstead Nursery, a residential nursery for infants and young children who have lost their homes, and often also their parents, as the result of war conditions, which was described in a previous publication by the same authors, *Young Children in War-Time.* This study is devoted to a comparison of the general development of these children with that of children living a normal family life. It seems that although up to 5 months the infant in the residential nursery may develop relatively well, because physical conditions are superior to those of the ordinary working-class home; yet after that age the residential nursery child is usually at a disadvantage. The lack of the continuous and intimate emotional relationship with the mother, and of the other contacts of normal family life, produce a retardation in emotional development, intellectual and speech development, and habit training. The institutional children are insecure, more clinging to adults and more aggressive to one another, and indulge in more phantasy life and auto-erotic gratification, than do normal children. Finally it seems possible that the development of character and 'conscience' is impeded by the lack of the normal love objects, who at the same time represent the demands and regulations of society, with which the child can identify himself. These difficulties can be overcome to some extent by providing a 'mother substitute', a nurse who has more or less complete charge of a group of children of different ages. But if the adults in charge of the child remain remote and impersonal, the child's social adaptation may remain superficial and incomplete.

A further study of these children as they grow up may show how far these prognostications are correct. Meanwhile, the present study is most interesting and valuable, and admirably carried out up to a point—though, as with the previous study, one would like to know the actual frequency distribution of the deficiencies described.

The Psychology of Cultural Change in Painting. By R. W. PICKFORD. British Journal of Psychology Monograph Supplements, No. XXVI. Cambridge University Press. 1943. Pp. 62. 8*s.* 6*d.* net.

It is, of course, quite true to point out, as Dr Pickford does, that no painter works in a social vacuum, but that he must be influenced to some degree by the social groups to which he belongs, their traditions and attitudes. This influence is quite clear in the case of the lesser painters of, for instance, the great Italian schools; and also in some of the lesser schools such as the Barbizon and Pre-Raphaelite, which Dr Pickford describes. He demonstrates convincingly the effects of general social change upon the work of such groups, e.g. of the interest in naturalism upon the Barbizon painters and of the revolt against industrialism upon the Pre-Raphaelites. He also analyses the even greater effect of borrowing and of contact of cultures upon the Mogul miniature painters and the Russian ikon painters, whose work was highly stereotyped by social tradition. But when we consider the great painters, it is far easier to see how they have influenced other painters, and also general aesthetic taste, than that they have themselves been affected either by family relationships, or by traditional styles of painting or by general social factors. Not even the Freudian can *explain away* the innovations of a Leonardo or a Cézanne in any other terms than those of artistic creative ability. In so far as they were subject to social influences and social changes, the effect upon their painting was far otherwise than the comparatively clear and straightforward effects upon that of the lesser painters. Dr Pickford comments on this distinction, but does not make it sufficiently clear. It seems doubtful if anyone in the present state of our knowledge could clarify it all satisfactorily.

BRITISH PSYCHOLOGICAL SOCIETY

REVENUE ACCOUNT AND BALANCE SHEET AS AT 31 DECEMBER 1943

Revenue Account for the year ended 31 December 1943

1942			Expenditure						1942			Income					
£	s.	d.		£	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.
100	0	0	*To* Rent				100	0	0				*By* Subscriptions 1941/42	2	8	6			
			Rates from 24/6/41				118	6	3				Subscriptions 1943	1578	2	0			
29	0	7	Lighting, Heating and Cleaning ...				29	1	5					1580	10	6			
332	7	1	Salaries and State Insurance ...				337	17	0				*Less* Resignations, Removals and Suspended Memberships	137	3	3			
92	18	9	Printing and Duplicating				95	11	0								1443	7	3
12	19	9	Expenses of Meetings				13	10	6	1310	8	2							
			Travelling Expenses				9	4	8				Transfer Fees:						
84	11	6	Postages and Telephone				84	4	8				Fellows (17)	8	18	6			
20	7	2	Stationery				14	7	10				Associates (22)	12	12	0			
21	16	6	Insurance				17	1	3										
12	12	0	Audit Fee 1943				12	12	0	201	1	6					21	10	6
9	15	2	Teas				7	3	3	134	8	1	Interest on Investments				142	17	9
10	17	8	Sundry Expenses				9	13	10				Balance, being Excess of Expenditure over Income				73	13	6
19	5	0	*Pamphlet: Under Fives*																
			Journals Publication Expenses:																
	258	1 4	General	280	15	9													
			Medical	304	6	8													
	104	2 0	Educational	130	13	0													
362	3	4					715	15	5										
24	11	8	Extended General Meeting 1943 ...				33	9	9										
7	10	10	Scottish Branch Expenses				7	7	8										
			Midland Branch Expenses				1	19	7										
4	5	0	Bank Charges and Cheque Books ...				1	17	1										
23	12	10	*Legal Expenses*																
			Depreciation:																
			Library	54	5	10													
			Office Furniture and Fittings ...	18	0	0													
75	2	6					72	5	10										
1243	17	4																	
402	0	5	*Surplus*																
£1645	17	9					£1681	9	0	£1645	17	9					£1681	9	0

Balance Sheet as at 31 December 1943

1942 £ s. d.	Liabilities	£ s. d.	£ s. d.
16 12 0	Sundry Creditors		22 8 2
52 9 4	Subscriptions in Advance ...		30 8 6
	Publications Reserve:		
122 0 0	Balance as per last Balance Sheet		122 0 0
	Revenue Account:		
5242 16 0	Balance as per last Balance Sheet	5644 16 5	
	Less Excess Expenditure of year	73 13 6	
5644 16 5			
402 0 5	*Surplus*		5571 2 11
£5835 17 9			£5745 19 7

1942 £ s. d.	Assets	£ s. d.	£ s. d.
606 15 1	Cash at Barclays Bank Ltd.		136 17 4
2 12 0	Postage Stamps in hand		1 15 6
	Investments at Cost:		
	£3514. 9*s.* 6*d.* 3½% Inscribed War Loan	3625 7 9	
	£1000 3% Defence Bonds	1000 0 0	
4125 7 9			4625 7 9
	Note: Market value of above Securities at 31 December 1943, £4640		
2 16 1	Sundry Debtors		16 6
207 7 0	Subscriptions in Arrear		137 2 0
	Office Furniture and Fittings:		
	Balance as per last Balance Sheet ...	180 0 0	
	Less Depreciation	18 0 0	
180 0 0			162 0 0
	Library:		
	Balance as per last Balance Sheet ...	502 10 0	
	Add Expenditure during year ...	38 15 10	
		541 5 10	
	Less Depreciation	54 5 10	
502 10 0			487 0 0
	Monograph Publications:		
	Balance as per last Balance Sheet ...	158 9 10	
	Add Grant during year	40 0 0	
		198 9 10	
	Less Amounts repaid during year ...	53 9 4	
158 9 10			145 0 6
50 0 0	Shares in the British Journal of Educational Psychology Ltd., at Cost ...		50 0 0
£5835 17 9			£5745 19 7

Auditor's Report to the Members: I have audited the above Balance Sheet dated 31 December 1943, and have obtained all the information and explanations I have required. In my opinion the above Balance Sheet is properly drawn up so as to exhibit a true and correct view of the Society's affairs according to the best of my information and the explanations given to me and as shown by the Books of the Society.

T. BARRETT,
Incorporated Accountant,
Auditor
17 *February* 1944

S. J. F. PHILPOTT,
Hon. Treasurer
T. H. PEAR,
President